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A STUDY OF THE BACTERIAL CONTAMINATION OF HILLSIDE SPRING AT PLATT NATIONAL PARK

Robert S. Kerr Water Research Center
Ada, Oklahoma

January 1968

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A STUDY OF THE BACTERIAL CONTAMINATION OF HILLSIDE SPRING AT PLATT NATIONAL PARK

Prepared for

PLATT NATIONAL PARK

Sulphur, Oklahoma

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U. S. Department of the Interior
Federal Water Pollution Control Administration
Robert S. Kerr Water Research Center
Technical Services Program
Ada, Oklahoma

January 1968

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I. INTRODUCTION

Purpose and Scope

Hillside Spring has a long history of intermittent bacterial contamination. A warning sign has been posted over the fountain for many years. (See Figure 1) Based on this history of bacterial contamination, the National Park Service requested by letter of November 9, 1966, the assistance of the Technical Services Program at the Robert S. Kerr Water Research Center in conducting a study to determine the source of contamination. (Letter in Appendix)

The letter of request for assistance stated that the Service was interested in developing this spring for drinking water supply for use by the visiting public. The objective of this study was to determine if the water was of adequate bacteriological quality to meet the *U. S. Public Health Service Drinking Water Standards* as published in 1962. Therefore, an extensive study of bacteriological parameters with routine screening for chemical parameters was undertaken.

Conclusions and Recommendations

The study indicates that the bacterial contamination from Hillside Spring is of soil origin. During the dry period the total coliform counts were 100 percent non-fecal organisms. During the wet period the contamination, as indicated by both fecal coliform and fecal streptococci, was from the avian and mammalian species that are natural to the area. Since there is no apparent gross contamination from the bacteriological standpoint, it would appear that treatment similar to that presently being used on Bromide and Medicine Springs would completely alleviate the bacterial contamination problem from Hillside Spring.

It is further noted that all chemical parameters determined for Hillside Spring are well within the *U. S. Public Health Service Drinking Water Standards* - 1962.[6]

From the sanitary aspect, the quality of the raw water from Hillside Spring is excellent for a potential potable source. It would, however, require some treatment to alleviate the slight bacterial contamination.

It is recommended that consultation be requested of the Department of Health, Education, and Welfare pursuant to the provisions of the Interdepartmental Agreement dated August 8, 1966, so that the officials of Platt National Park may be advised of the necessary measures to be taken in order to develop Hillside Spring for public drinking water supply.

Authority

This study was made under the provisions of the Federal Water Pollution Control Act as amended (33 U.S.C. 466 et seq), Section 5.

Acknowledgments

The help and cooperation of the following organizations and persons are gratefully acknowledged:

Officials of Platt National Park;

Mr. L. D. Drake, Maintenance Foreman (retired), Platt National Park.

II. DESCRIPTION OF THE PROJECT

Location

The study area is in Murray County, Oklahoma, adjacent to the south edge of the town of Sulphur. U. S. Highway 177 running north and south bisects the park. (See Figure 7).

Of primary importance in this study is Hillside Spring. This spring is located about 1,800 feet south of the main north park entrance and about 100 feet to the west side of Highway 177. For exact location of Platt National Park and Hillside Spring refer to Figure 6.

Description of Hillside Spring

The park service has improved Hillside Spring with a concrete cistern. The water from the spring flows upward through a 14-inch diameter tile, which is about three feet long. This water then overflows into the concrete cistern built in a rectangular shape around the tile. Inside this cistern is a two-inch overflow pipe which, when the cistern fills to a level of about three and one-half feet, leads to the fountain as shown in Figures 2, 3, and 5. The samples for both bacteriological and chemical parameters were taken from the two-inch pipe located in the center of the fountain pool as illustrated in Figure 3. The other four springs--Pavilion, Black Sulphur, Bromide, and Medicine-- were sampled routinely for background and correlative information only.

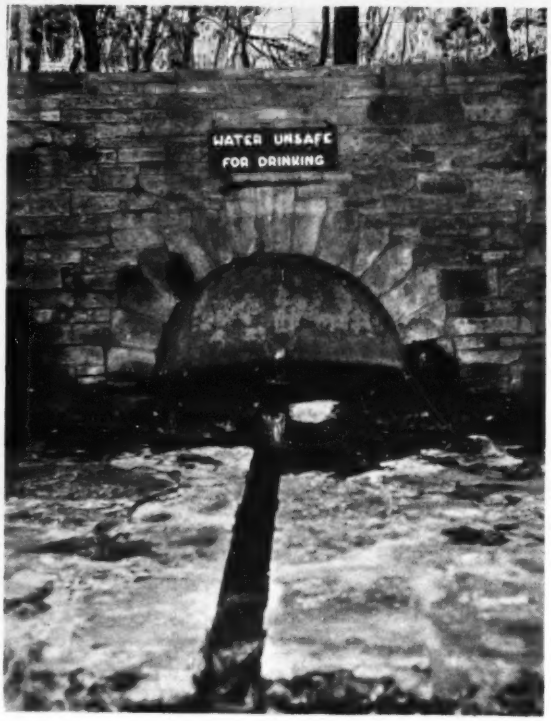

Figure 1. Warning sign designating that the water from Hillside Spring is unsafe for drinking.

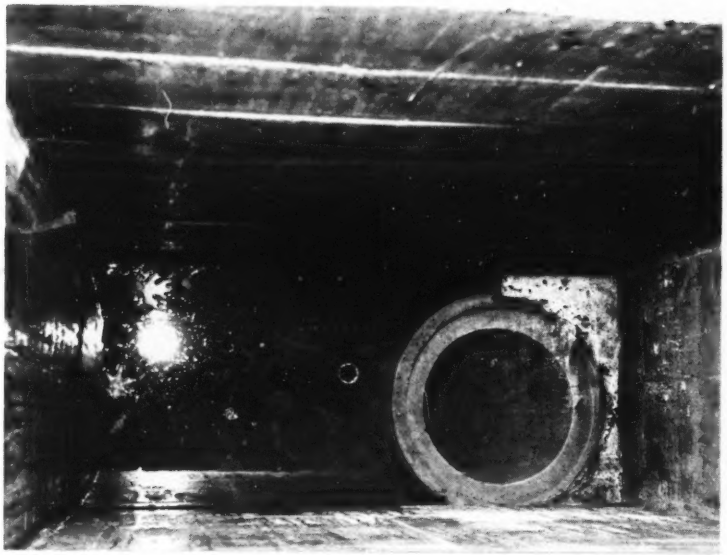

Figure 2. Top view illustrating the 14-inch tile and overflow to fountain. Note the water level in cistern.

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CONSTRUCTION OF IMPROVEMENTS

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FIGURE 1 and 2

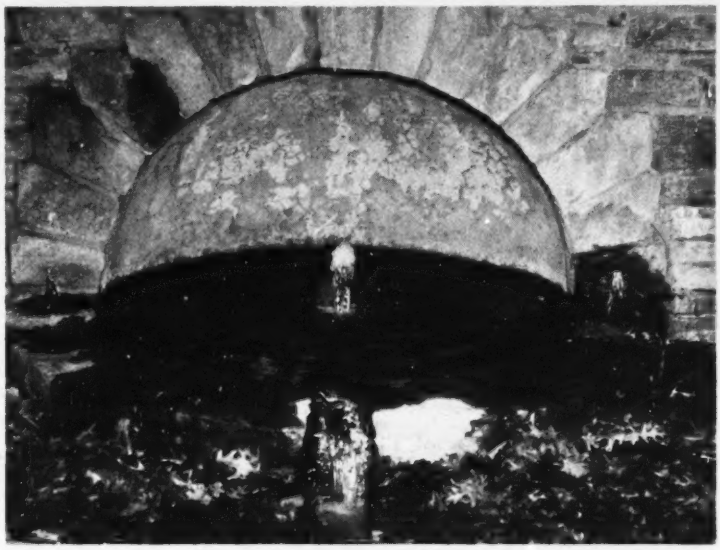

Figure 3. Fountain at Hillside Spring. The center discharge pipe is the sampling station. Samples for all parameters studied were collected from this center discharge pipe.

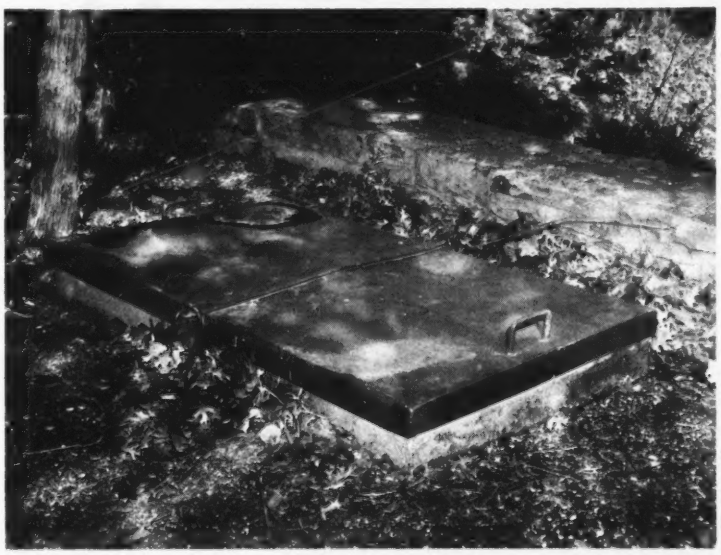

Figure 4. The metal cover over the cistern at Hillside Spring.

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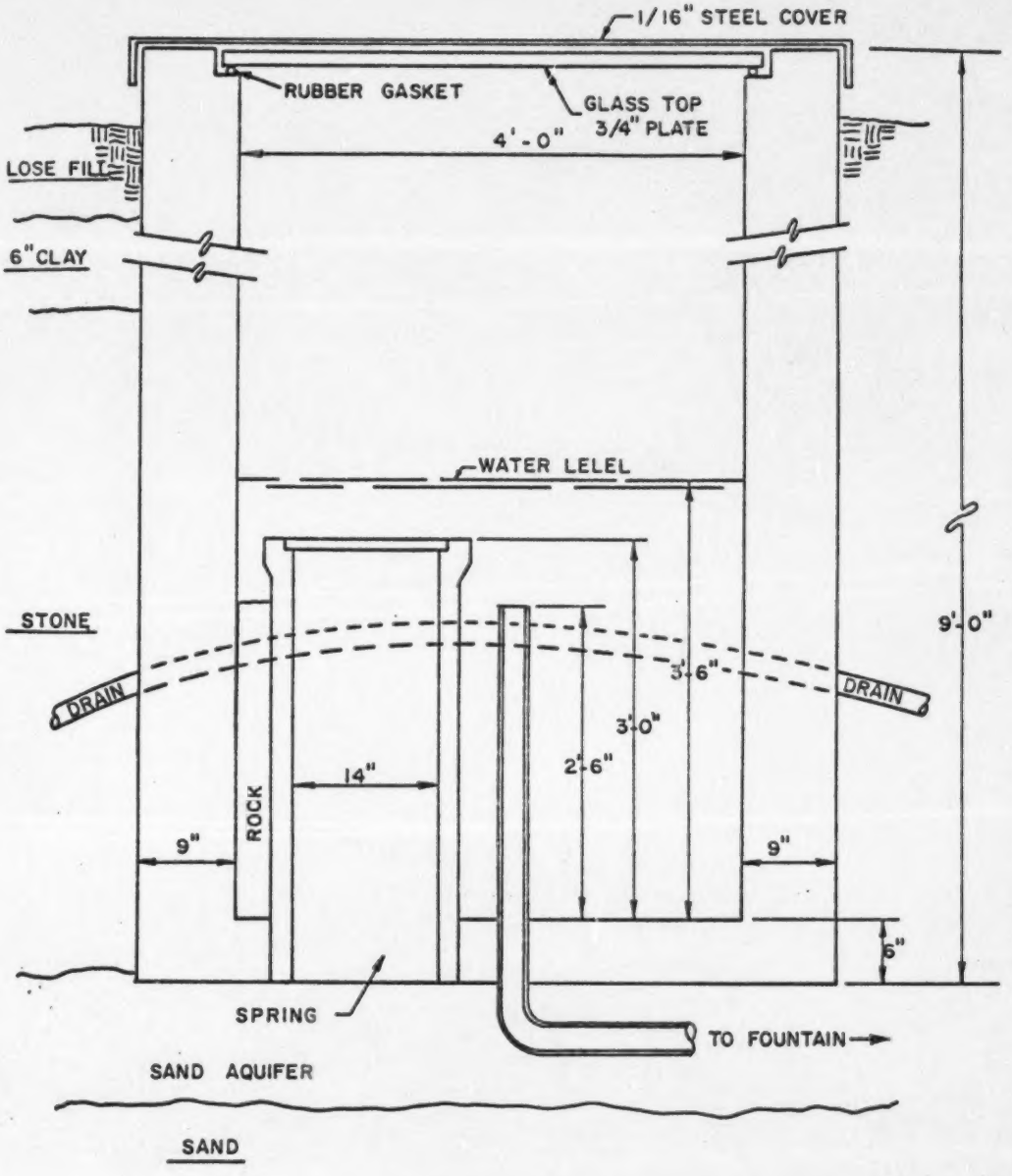
FIGURE 3 and 4



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CONSTRUCTION OF HILLSIDE SPRINGS

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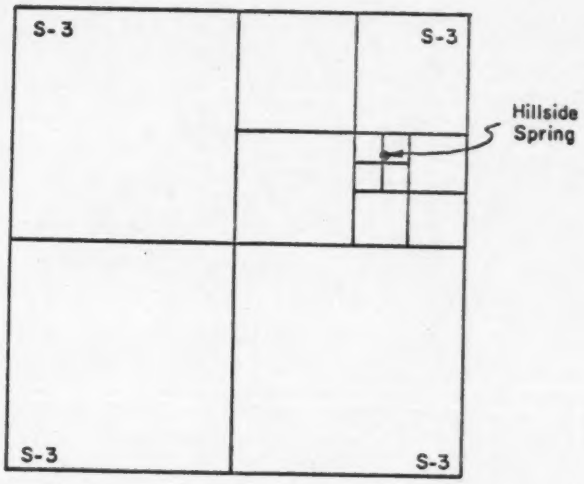
FIGURE 5



HILLSIDE SPRING— SW of 1/4 of NE 1/4 of NW 1/4 of SE 1/4 of NE 1/4 of Sec. 3, T-1-S, R-3-E Murray, County, Oklahoma

PLATT NATIONAL PARK — Parts of Sec. 34-35, T-1-N, R-3-E And Parts of Sec. 1-2-3-and 4 T-1-S, R-3-E Murray, County, Oklahoma

A STUDY OF THE BACTERIAL CONTAMINATION OF HILLSIDE SPRINGS AT PLATT NATIONAL PARK

LEGAL DESCRIPTION OF SAMPLING STATION AND PLATT NATIONAL PARK

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ADA, OKLAHOMA

FIGURE 6

III. DESCRIPTION OF ANALYTICAL METHODS

Microbiological Methods

The microbiological parameters were determined at the Robert S. Kerr Water Research Center in Ada, Oklahoma. The procedures used were in accordance with *Standard Methods for the Examination of Water and Wastewater*, Twelfth Edition, 1965, under the chapter entitled "Test for Presence of Members of Coliform Group by Membrane Filter Technique."[2] Since the waters examined were potentially for potable water supply there was sufficient parallel testing by the Multiple-Tube Fermentation Technique to validate the Membrane Filter Technique.

The procedures used for enumerating the presence of fecal streptococcal group were those described in *Standard Methods* under the chapter entitled "Test for the Presence of Fecal Streptococcal Group (Tentative) Part A, Membrane Filter Technique."[2] The enumeration of the fecal coliform group was by the Membrane Filter Technique. Geldreich, Clark, et al, describe the elevated temperature techniques for the cultivation of the fecal coliform group which were followed on this project.[6 12 19 24 25] This test is not described in *Standard Methods*. However, it has been thoroughly studied by many investigators in the field of water quality.[8 9 12 19 24] Each has shown this test to be reliable for the enumeration of the fecal coliform group.

Plates were poured of plate count media for the enumeration of the Heterotropic bacteria. Samples were filtered by the Membrane Filter method. The membranes were then placed on the solidified plate count media and then incubated for the specified time. Two sets were filtered. One set was incubated at 35°C for 24 hours, the other set was incubated at 20°C for 48 hours. The pads for both incubation periods were flooded with methylene blue dye to stain the colonies as an aid in counting the colonies on each plate.

The media used for the various parameters were as follows:

1. Total Coliform - M-Endo (Difco)
2. Fecal Coliform - M-FC (Difco)
3. Fecal Streptococci - M-enterococci agar (Difco)
4. 35°C and 20°C Heterotrophic - Plate Count agar (Difco)

To sterilize the funnel assembly used in the procedures, the ultra-violet sterilizers were used as described by Rhines and Cheevers.[22] According to Milmed,[19] all samples should be tested perferably within one hour after they have been collected. On this study all samples were tested within two hours after collection. The samples were collected and transported directly to the Robert S. Kerr Water Research Center by the Officials of Platt National Park.

The samples were taken by grab method. The water was taken directly from the pipe in the center of the fountain as shown in Figure 3. The spring has a continuous flushing action that to grab a sample from this pipe will give an accurate representative sample from the spring. At Pavilion Spring the sample was taken as the water overflowed a rock directly encasing the spring head. The other three springs (Black Sulphur, Medicine, and Bromide) were taken by lowering the wide mouth bottles on a sampler developed at this laboratory and collecting the sample at approximately six inches below the surface. Aseptic techniques were employed throughout the sampling program. Samplers and wide mouth bottles were wrapped in 24-ounce brown wrapping paper and sterilized at 121 psi for 30 minutes. Samples which required diluting were diluted in sterile phosphate buffer at a ratio of 1:100. Sterile phosphate buffer was used to rinse the funnel assembly between samples.

Total coliform and fecal streptococci cultures were incubated at 35°C for the recommended time intervals as described in *Standard Methods*[2]. The fecal coliform cultures were placed in an 18-ounce plastic bag and immersed for 24 hours at 44.5°C.

Sterile membrane filters, white, grid, having pore openings of 0.45μ, and 47 millimeters in diameter were used for all parameters evaluated.

Chemical Methods - Laboratory

The methods set forth in *Standard Methods for the Examination of Water and Wastewater*, Twelfth Edition, 1965, were used for the chemical and physical parameters analyzed on this survey. Potassium persulfate was used in the digestion step of the total phosphate phosphorus analyses.

Parameter	Method
pH	*Standard Methods for the Examination of Water and Wastewater*, Twelfth Edition, 1965, page 225.
Dissolved Oxygen	*Standard Methods for the Examination of Water and Wastewater*, Twelfth Edition, 1965, page 405.
Total Suspended Solids	*Standard Methods for the Examination of Water and Wastewater*, Twelfth Edition, 1965, page 424, Method C.
Total Solids	*Standard Methods for the Examination of Water and Wastewater*, Twelfth Edition, 1965, page 423, Method A.
Organic Nitrogen	*Standard Methods for the Examination of Water and Wastewater*, Twelfth Edition, 1965, page 208.
Ammonia Nitrogen	*Standard Methods for the Examination of Water and Wastewater*, Twelfth Edition, 1965, page 187, Distillation Method.
Nitrate Nitrogen	*Standard Methods for the Examination of Water and Wastewater*, Twelfth Edition, 1965, page 198, Brucine Method
Nitrite Nitrogen	*Standard Methods for the Examination of Water and Wastewater*, Twelfth Edition, 1965, page 205.
Total Phosphate	*Standard Methods for the Examination of Water and Wastewater*, Twelfth Edition, 1965, page 236.
Bromide	*Standard Methods for the Examination of Water and Wastewater*, Twelfth Edition, 1965, page 66.

Parameter	Method
Chloride	*Standard Methods for the Examination of Water and Wastewater*, Twelfth Edition, 1965, page 87, Mercuric Nitrate Method.
Hardness	*Standard Methods for the Examination of Water and Wastewater*, Twelfth Edition, 1965, page 147, EDTA Titrametric Method.
Conductivity	*Standard Methods for the Examination of Water and Wastewater*, Twelfth Edition, 1965, page 280.
Sulfide	*Standard Methods for the Examination of Water and Wastewater*, Twelfth Edition, 1965, page 427.
Phenol	*Standard Methods for the Examination of Water and Westewater*, Twelfth Edition, 1965, page 517, Method A.
Sulfite	*Standard Methods for the Examination of Water and Wastewater*, Twelfth Edition, 1965, page 294.
Chemical Oxygen Demand	*Standard Methods for the Examination of Water and Wastewater*, Twelfth Edition, 1965, page 510.
Biochemical Oxygen Demand (5 day)	*Standard Methods for the Examination of Water and Wastewater*, Twelfth Edition, 1965, page 415.
Fluoride	*Standard Methods for the Examination of Water and Wastewater*, Twelfth Edition, 1965, page 144, SPADNS Method.
Sulfate	*Standard Methods for the Examination of Water and Wastewater*, Twelfth Edition, 1965, page 291.

IV. DISCUSSION OF DATA

Microbiological Data

At the inception of this study Hillside Spring only was sampled. After nine days of sampling and with no indication of a bacterially polluted spring, it was decided to study the other mineral springs in the park. The study of other mineral springs was instigated to determine if their waters were of the same quality as that of Hillside Spring. At the time the study was extended to include the other four mineral springs, bacterial parameters were expanded to include the 20°C and 35°C incubator temperatures for heterotrophic bacteria on all springs. Scarce[23] found that one can expect higher heterotrophic bacterial densities in waters not subject to organic pollution when incubated at 20°C than those incubated at 35°C, and in recently polluted waters this relationship may reverse in proportion to the amount of pollution.

When the logarithmic averages of heterotrophic bacterial densities were calculated on each of the springs, the 20°C incubation temperatures were greatest on those springs whose densities were high enough to be of significance. The data in tables I and II indicate the extremely low levels of pollution when the total coliform, fecal coliform, and fecal streptococci parameters are evaluated with the heterotrophic data.

In order to test whether the data collected in the wet period differed from that collected in the dry period in either dispersion or central tendency, the Kolmogorov-Smirnov two-sample test was used. A maximum difference of 14 was observed. The probability of a difference of this magnitude occurring when the two sets of data do not differ is less than .005; therefore, the conclusion is that the two periods do differ.

As shown in Table I, the paucity of both fecal coliform or fecal streptococci is a definite indication that the coliform densities found during the dry period on Hillside Spring were of soil origin. In Table VII it is observed that the logarithmic average of the coliform density of Hillside Spring is greater than any of the other springs under study during the dry period. This minor difference in bacterial densities is due to the .71 inches of rainfall on March 25, 1967.

The wet period is defined as that period when rainfall is sufficient to have an effect on the spring, and continues until the effect is no longer observed.

As observed in Table I, there was a rapid rise and fall of the total coliform densities during the period following the .71 inches of rainfall. It was during the period of precipitation that

fecal coliform was first isolated from Hillside Spring. From this observation it was suspected that the contamination was entering the aquifer of Hillside Spring in the immediate proximity of the spring. This hypothesis was drawn because of the rapidity with which the increase and decrease in the bacterial densities occurred. This phenomena can also be observed during the periods of heavy precipitation as indicated in Table II.

Hillside Spring exhibited very low bacterial densities during the dry period. The logarithmic average for total coliform was 2/100ml. (See table VII) The range from a low to high count is <1-20/100ml. The fecal coliform and fecal streptococci logarithmic averages were <1/100 and <1/100 ml, respectively.

During the dry period the heterotrophic parameters are further evidence that the bacterial densities in Hillside are from a non-pollutional source. During this period the flow of .033 CFS remained constant. As stated earlier, in only one instance was there sufficient precipitation to cause any change in the bacterial densities during the period of study designated as the dry period. (See Table I)

The period designated as the wet period extended from April 10 through May 22. During this period the total coliform range was 6-1200/100 ml with a logarithmic average of 39/100 ml. The fecal coliform and fecal streptococci ranges were <1-29/100 ml and <1-540/100 ml, respectively. (See Table II) The logarithmic averages for fecal coliform and fecal streptococci were 2/100 ml and 13/100 ml, respectively.

Again as shown in Table II, the heterotrophic bacteria support the theory that the bacterial contamination is coming from an insignificant pollution source, as illustrated by greater densities when incubated at 20°C. The phenomena was again observed, whereby the rapid increase and decrease in the bacterial counts occur shortly after significant precipitation. The pattern remained constant with little variation in time as shown in Table II.

Both Pavilion and Black Sulphur Springs (Tables III and IV) exhibited little or no indication of bacterial pollution. Pavilion Spring remained constant through wet and dry periods. During the entire study no coliform or fecal streptococci were isolated. The heterotrophic bacterial counts, 35°C and 20°C, during the dry period were 1-60/100 ml and 1-37/100 ml, respectively. Ranges for the heterotrophic bacterial counts, 35°C and 20°C during the wet period were 4-260/100 ml and 2-348/100 ml, respectively. On Pavilion Spring there was a reversal in the heterotrophic densities of the two incubation periods. The probability is that this reversal was due to the

paucity in the heterotrophic bacterial densities. It is therefore insignificant from the water quality standpoint of this spring. Black Sulphur Spring exhibited no indication of bacterial pollution during the dry period. The heterotrophic bacterial densities are also evidence that there is no organic pollution in this spring. The wet period did show some rise in coliform and fecal streptococci densities during the heavy precipitation. The range in total coliform densities was <1-54/100 ml with a logarithmic average of <1/100 ml. The ranges for fecal coliform and fecal streptococci were <1-7/100 ml and <1-3/100 ml, respectively. (See Table IV) Logarithmic average of both fecal coliform and fecal streptococci was <1/100 ml.

At the recommendation of the U. S. Public Health Service, the Park Service installed an ultra-violet light on the waterline running from Black Sulphur Spring to the hydrants used by the public. It is noted that all samples analyzed were taken before the water passed through the ultra-violet light.

The coliform densities in Bromide and Medicine Springs closely parallel the coliform densities of those found in Hillside Spring. During the dry periods the two coliform and fecal streptococcal parameters were slightly lower than those of Hillside. Table VII illustrates that this difference is most insignificant. The total coliform density range during the dry period was <1-3/100 ml; the logarithmic average was 1/100 ml; and the fecal coliform and fecal streptococci range was <1/100 ml and <1-2/100 ml, respectively. (See Table VII)

It is apparent that the waters from both Medicine and Bromide Springs do not maintain as high quality of water as Hillside Spring when compared to the 20°C and 35°C heterotrophic densities, yet the pollutional indicator systems fall within the same range. The range of the heterotrophic bacterial densities for both wet and dry periods is illustrated in Table VII.

Medicine Spring more closely parallels the coliform and fecal streptococcal densities of Hillside Spring than any of the other springs during the wet periods.

The range and logarithmic averages for total coliform, fecal coliform, and fecal streptococci during both wet and dry periods are illustrated in Table VII.

It is significant to note that the park authorities have installed chlorinating systems on both Medicine and Bromide Springs. This chlorinated water is pumped into storage tanks located in the Bromide pavilion. From data obtained on the raw water of these two springs it was found that this treatment is necessary to insure the potability of the water from both springs.

During periods of precipitation a rapid increase in coliform densities was observed. Therefore, an on-the-spot investigation was made during periods of rain to observe runoff and the points where the water would percolate into the ground. It was observed that the land immediately to the south and west of Hillside Spring sloped toward the spring. Therefore, the runoff would flow toward the spring. It is hypothesized that this point of recharge is the source of bacterial contamination to Hillside Spring.

Tracer Study

From this hypothesis, tracer studies were designed to prove or disprove this theory.

A 10 percent brine solution of >8,000 micromhos conductivity was used as the tracer for this study. A continuous-recording conductivity meter was then installed in the two-inch pipe of the fountain. Ten gallons of the brine solution were intruded at the point where the runoff was observed percolating into the ground. After seven days no change was detected in the conductivity of the spring. However, upon discussing the construction of the structure at the spring with the former maintenance superintendent of the Park it was learned that drain tile was placed around this concrete encasement. From this information the conductivity was measured at the point of discharge from this drain tile. It was observed that an increase of 1,450 micromhos occurred at about the same time lapse as the increase of the bacterial densities when compared to the time of brine intrusion with the time of rainfall. In the construction of this encasement there was a layer of clay fill at about the four and one-half foot level extending out from the encasement for several feet. It was felt that this clay fill was sealing off the brine solution from entering the aquifer.

Following this experiment, seven shallow basins were drilled for points of brine intrusion about six feet farther uphill in an attempt to allow the brine to pass under this clay fill. This procedure was also unsuccessful. All tracer studies were unsuccessful in determining the exact area in which the contamination is occurring.

Spring Flow Characteristics

The flow of Hillside Spring is very stable during both wet and dry seasons. There was very little fluctuation during this period of study. (Tables I and II)

TABLE I

Hillside Spring (Dry Period)
Microbiological Results (Membrane Filter)

Date	Total Coliform/ 100ml	Total Coliform/ 100ml	Fecal Strep/ 100ml	Heterotrophic 35°C/ 100ml	Heterotrophic 20°C/ 100ml	Flow CFS	Inches of Rainfall	Temp °C
1-28						.042		
1-30	5	<1	<1			.033		19
1-31	3	<1	<1			.033		19
2- 1	4	<1	1			.033	.67	19
2- 2	5	<1	<1			.033		19
2- 3	6	<1	<1			.033		19
2- 4	<1	<1	1			.033		19
2- 5	2	<1	<1			.033		19
2- 6	2	<1	<1			.033		19
2-11							.11	
2-14	1	<1	<1			.033		19
2-15	3	<1	<1			.033		19
2-20	3	<1	<1			.033		19
2-21	1	<1	<1			.033		19
2-22	2	<1	1			.033		19
2-23	2	<1	<1			.033		19
2-24	<1	<1	<1			.033		19
2-25	3	<1	<1			.033		19
2-26	2	<1	<1			.033		19
2-27	<1	<1	<1			.033		19
2-28	1	<1	<1			.033	.01	19
3- 1	<1	<1	<1			.033		19
3- 7						.033	.10	
3- 8	<1	<1	<1			.033		19
3-13	<1	<1	<1	30	155			-
3-14	1	<1	<1	27	71	.033		19
3-15	<1	<1	<1	8	40	.033		19
3-20	<1	<1	<1	4	81	.033	.18	19
3-21	1	<1	<1	30	164	.033		19
3-22	<1	<1	<1	12	140	.033		19
3-25						-	.71	19
3-27	2	1	<1	68	180	.033		19
3-28	20	16	1	112	188	.033		19
3-29	2	1	<1	TNTC	TNTC	.033		19
3-30	2	<1	<1	50	113	.033		19
3-31	<1	<1	<1	129	285	.033		19

TABLE II

Hillside Spring (Wet Period)
Microbiological Results (Membrane Filter)

Date	Total Coliform/ 100ml	Fecal Coliform/ 100ml	Fecal Strep/ 100ml	Heterotrophic 35°C/ 100ml.	Heterotrophic 20°C/ 100ml	Flow CFS	Inches of Rainfall	Temp °C
4- 8						.028	.16	
4-10	TNTC	16	219	TNTC	-	.028	1.76	19
4-11	38	1	18	8,400	-	.028	1.21	19
4-12	490	29	540	TNTC	TNTC	.064	1.34	19
4-13	1,200	14	350	90,000	480,000	.053	2.82	19
4-14	190	1	44	7,800	42,000	.028		19
4-15	75	<1	5	3,000	10,000	.028		19
4-16	40	1	<1	2,100	8,200	.023		19
4-17	6	<1	25	1,000	1,200	.028		19
4-18	6	<1	4	830	1,055	.033		19
4-19	21	<1	<1	830	2,270	.033		19
4-24	12	<1	7	690	2,400	.028		19
4-25	13	<1	15	750	820	.028		19
5- 1	28	<1	16	-	-	.028		19
5-10	17	1	<1	810	970	.028		19
5-21							1.70	
5-22	28	<1	1	400	450	.028		19

TABLE III

Pavilion Spring (Dry Period)
Microbiological Results (Membrane Filter)

Date	Total Coliform/ 100ml	Fecal Coliform/ 100ml	Fecal Strep/ 100ml	Heterotrophic 35°C/ 100ml	Heterotrophic 20°C/ 100ml
2-14	<1	<1	<1		
2-20	<1	<1	<1		
2-21	<1	<1	<1		
2-22	<1	<1	<1		
2-23	<1	<1	1		
2-24	<1	<1	<1		
2-25	<1	<1	<1		
2-26	<1	<1	<1		
2-27	<1	<1	<1		
2-28	<1	<1	<1		
3- 1	<1	<1	<1		
3-13	<1	<1	<1	5	5
3-14	<1	<1	<1	1	1
3-15	<1	<1	<1	3	11
3-20	<1	<1	<1	3	1
3-21	<1	<1	<1	1	9
3-22	<1	<1	<1	7	9
3-27	<1	<1	<1	60	37
3-28	<1	<1	<1	20	2
3-29	<1	<1	<1	<1	16
3-30	<1	<1	<1	49	2
3-31	<1	<1	<1	9	5
		(Wet Period)			
4-10	<1	<1	<1	95	-
4-11	<1	<1	<1	17	-
4-12	<1	<1	<1	260	27
4-13	<1	<1	<1	18	348
4-14	<1	<1	<1	11	4
4-15	<1	<1	<1	8	40
4-16	<1	<1	<1	8	16
4-17	<1	<1	<1	125	9
4-18	<1	<1	<1	12	16
4-19	<1	<1	<1	25	2
4-24	<1	<1	<1	128	12
4-25	<1	<1	<1	4	12
5- 1	<1	<1	<1	-	-
5-10	<1	<1	<1	31	28
5-22	<1	<1	<1	13	7

TABLE IV

Black Sulphur Spring (Dry Period)
Microbiological Results (Membrane Filter)

Date	Total Coliform/ 100ml	Fecal Coliform/ 100ml	Fecal Strep/ 100ml	Heterotrophic 35°C/ 100ml	Heterotrophic 20°C/ 100ml
2-14	<1	<1	<1		
2-20	<1	<1	<1		
2-21	<1	<1	<1		
2-22	<1	<1	<1		
2-23	<1	<1	<1		
2-24	<1	<1	<1		
2-25	<1	<1	<1		
2-26	<1	<1	<1		
2-27	<1	<1	<1		
2-28	<1	<1	<1		
3- 1	<1	<1	<1		
3-13	<1	<1	<1	10	25
3-14	<1	<1	<1	<1	4
3-15	<1	<1	<1	2	39
3-20	<1	<1	<1	1	33
3-21	<1	<1	<1	9	50
3-22	<1	<1	<1	6	19
3-27	<1	<1	<1	128	207
3-28	<1	<1	<1	9	3
3-29	<1	<1	<1	23	23
3-30	<1	<1	<1	4	20
3-31	<1	<1	<1	9	23
		(Wet Period)			
4-10	<1	<1	<1	78	-
4-11	<1	<1	<1	20	-
4-12	<1	<1	<1	TNTC	970
4-13	<1	<1	<1	2	152
4-14	<1	<1	<1	21	14
4-15	<1	<1	<1	20	53
4-16	<1	<1	<1	66	40
4-17	8	<1	<1	396	152
4-18	54	7	<1	230	TNTC
4-19	7	<1	<1	160	210
4-24	1	<1	3	486	94
4-25	<1	<1	<1	5,550	6,000
5- 1	<1	<1	<1	-	-
5-10	<1	<1	<1	170	195
5-22	<1	<1	<1	5	5

TABLE V

Bromide Spring (Dry Period)
Microbiological Results (Membrane Filter)

Date	Total Coliform/ 100ml	Fecal Coliform/ 100ml	Fecal Strep/ 100ml	Heterotrophic 35°C/ 100ml	Heterotrophic 20°C/ 100ml
2-14	<1	<1	<1		
2-20	1	<1	<1		
2-21	-	-	-		
2-22	<1	<1	<1		
2-23	<1	<1	<1		
2-24	<1	<1	<1		
2-25	<1	<1	<1		
2-26	<1	<1	<1		
2-27	<1	<1	<1		
2-28	<1	<1	<1		
3- 1	<1	<1	<1		
3-13	<1	<1	2	420	TNTC
3-14	<1	<1	<1	1,550	TNTC
3-15	<1	<1	<1	1,100	41,700
3-20	2	<1	<1	100	18,200
3-21	1	<1	<1	500	18,900
3-22	1	<1	<1	380	17,800
3-27	2	<1	<1	6,400	24,000
3-28	3	<1	<1	2,000	24,900
3-29	<1	<1	<1	1,200	24,400
3-30	3	<1	<1	1,000	18,200
3-31	1	<1	<1	700	16,900
		(Wet Period)			
4-10	<1	<1	<1	6,000	-
4-11	3	<1	4	5,200	-
4-12	TNTC	<1	6	35,000	TNTC
4-13	340	4	33	720,000	TNTC
4-14	105	<1	4	2,100	41,000
4-15	200	<1	3	10,000	82,000
4-16	40	<1	<1	56,000	60,000
4-17	16	<1	<1	23,000	33,000
4-18	13	<1	1	3,000	24,000
4-19	4	2	2	6,000	5,000
4-24	34	<1	<1	2,400	10,700
4-25	<1	<1	2	3,000	9,700
5- 1	356	<1	4	-	-
5-10	158	<1	<1	2,000	7,900
5-22	<5	<1	<1	8,500	20,700

TABLE VI

Medicine Spring (Dry Period)
Microbiological Results (Membrane Filter)

Date	Total Coliform/ 100ml	Fecal Coliform/ 100ml	Fecal Strep/ 100ml	Heterotrophic 35°C/ 100ml	Heterotrophic 20°C/ 100ml
2-14	<1	<1	<1		
2-20	<1	<1	<1		
2-21	<1	<1	<1		
2-22	<1	<1	<1		
2-23	<1	<1	<1		
2-24	<1	<1	<1		
2-25	4	<1	<1		
2-26	12	<1	<1		
2-27	<1	<1	<1		
2-28	1	<1	<1		
3- 1	<1	<1	<1		
3-13	1	<1	<1	170	TNTC
3-14	<1	<1	<1	1,250	TNTC
3-15	<1	<1	<1	3,500	23,100
3-20	<1	<1	<1	600	4,000
3-21	<1	<1	<1	700	6,600
3-22	<1	<1	<1	800	11,900
3-27	<1	<1	<1	2,900	21,400
3-28	<1	<1	<1	2,800	16,700
3-29	1	<1	<1	600	34,000
3-30	<1	<1	<1	200	29,600
3-31	<1	<1	<1	1,800	35,400
		(Wet Period)			
4-10	<1	<1	<1	15,800	-
4-11	1	<1	<1	4,600	-
4-12	10	<1	<1	14,500	41,000
4-13	TNTC	92	380	56,000	TNTC
4-14	160	86	192	TNTC	TNTC
4-15	475	<1	600	54,000	297,000
4-16	260	89	222	101,000	199,000
4-17	150	68	160	115,000	92,000
4-18	32	10	30	9,000	64,000
4-19	24	11	36	18,000	92,000
4-24	TNTC	2	18	36,000	TNTC
4-25	15	8	33	57,000	80,000
5- 1	-	<1	12	-	-
5-10	-	<1	2	49,000	98,000
5-22	<4	<1	<1	11,000	15,000

TABLE VII

Microbiological Results (Membrane Filter)
Ranges and Logarithmic Averages during the Dry Period

	Total Coliform /100ml			Fecal Coliform /100ml			Fecal Streptococci /100ml			Heterotrophic 35°C /100ml			Heterotrophic 20°C /100ml		
	Hi	Lo	GM	Hi	Lo	GM	Hi	Lo	GM	Hi	Lo	GM	Hi	Lo	GM
Hillside	20	<1	2	16	<1	<1	1	<1	<1	129	4	9	285	40	24
Pavilion	<1	<1	<1	<1	<1	<1	<1	<1	<1	60	<1	6	37	1	5
Black Sulphur	<1	<1	<1	<1	<1	<1	1	<1	<1	128	<1	7	207	3	23
Bromide	3	<1	<1	<1	<1	<1	2	<1	<1	6,400	100	840	41,700	16,900	21,900
Medicine	12	<1	<1	<1	<1	<1	<1	<1	<1	3,500	170	928	35,400	4,000	21,400

Ranges and Logarithmic Averages during the Wet Period

Hillside	1,200	6	39	29	<1	2	540	<1	13	90,000	400	2,010	480,000	450	4,030
Pavilion	<1	<1	<1	<1	<1	<1	<1	<1	<1	260	4	25	348	2	16
Black Sulphur	54	<1	<1	7	<1	<1	3	<1	<1	5,550	2	76	6,000	5	554
Bromide	356	<1	25	4	<1	<1	33	<1	4	720,000	2,000	4,750	82,000	5,000	20,600
Medicine	475	<1	28	92	<1	5	380	<1	18	115,000	4,600	28,090	297,000	15,000	81,210

Discussion of Chemical Data

The Hillside Spring is within the limits of the *U. S. Public Health Service Drinking Water Standards* for the parameters analyzed. The Medicine, Bromide, Black Sulphur, and Pavilion Springs are above the standards for total dissolved solids.

Bromide Spring, unlike the others, exhibits a dissolved oxygen content which is unusual for spring waters.

The analyses indicated that Medicine Spring increases considerably in biochemical oxygen demand during periods of rainfall while the other springs increase only slightly.

Medicine and Bromide Springs exhibit a natural fluoride content above the *U. S. Public Health Service Drinking Water Standards* most of the time.

TABLE VIII

Hillside Spring Chemical and Physical Data

Parameter	Values		
	Maximum	Average	Minimum
pH	7.7	7.4	7.2
Dissolved Oxygen (DO), mg/l	0.0	0.0	0.0
5 Day (20°C) BOD, mg/l	4	1	0
Total Suspended Solids, mg/l	20	-	<7.0
Total Solids, mg/l	513	444	404
Organic Nitrogen as (N), mg/l	1.0	-	<.05
Ammonia Nitrogen as (N), mg/l	<.05	-	<.05
Nitrate Nitrogen as (N), mg/l	<.1	-	<.1
Nitrite Nitrogen as (N), mg/l	.006	-	<.005
Total Phosphate as (P), µg/l	75	-	<10
Bromide, mg/l	.34	.28	.21
Chloride, mg/l	103	65	55
Hardness as ($CaCO_3$), mg/l	294	287	270
Conductivity in (micromhos/cm at 25°C)	790	747	616
Sulfite, mg/l	.4	.2	.0
Phenol, mg/l	<.001	<.001	<.001
Chemical Oxygen Demand (COD), mg/l)	0.0	0.0	0.0
Sulfite, mg/l	<2	<2	<2
Fluoride, mg/l	.42	.35	.22

TABLE IX

Pavilion Spring Chemical and Physical Data

Parameter	Values		
	Maximum	Average	Minimum
pH	7.9	7.4	7.1
Dissolved Oxygen (DO), mg/l	0.0	0.0	0.0
5 Day (20°C) BOD, mg/l	1.5	.5	.1
Total Suspended Solids, mg/l	31	-	<7
Total Solids, mg/l	66	567	501
Organic Nitrogen as (N), mg/l	.4	-	<.05
Ammonia Nitrogen as (N), mg/l	.2	-	<.05
Nitrate Nitrogen as (N), mg/l	<.1	-	<.1
Nitrite Nitrogen as (N), mg/l	<.005	-	<.005
Total Phosphate as (P), µg/l	31	-	<10
Bromide, mg/l	.3	.3	.2
Chloride, mg/l	115	98	90
Hardness as ($CaCO_3$), mg/l	420	312	242
Conductivity in (micromhos/cm at 25°C)	1,020	921	856
Sulfide, mg/l	.7	.4	.1
Phenol, mg/l	0	0	0
Sulfite, mg/l	0	0	0
Chemical Oxygen Demand (COD), mg/l	19.9	6.2	0.0
Sulfate, mg/l	17.0	15.2	17.0
Fluoride, mg/l	.52	.39	.25

TABLE X

Black Sulphur Spring Chemical and Physical Data

Parameter	Values		
	Maximum	Average	Minimum
pH	7.6	7.4	7.3
Dissolved Oxygen (DO), mg/l	0.0	0.0	0.0
5 Day (20°C) BOD, mg/l	2.8	1.1	0.1
Total Suspended Solids, mg/l	35	-	<7
Total Solids, mg/l	642	603	582
Organic Nitrogen as (N), mg/l	.4	-	<.05
Ammonia Nitrogen as (N), mg/l	3.0	-	<.05
Nitrate Nitrogen as (N), mg/l	.2	-	<.1
Nitrite Nitrogen as (N), mg/l	<.005	-	<.005
Total Phosphate as (P), µg/l	25	19	15
Bromide, mg/l	.4	.4	.3
Chloride, mg/l	162	150	145
Hardness as ($CaCO_3$), mg/l	280	267	244
Conductivity in (micromhos/cm at 25°C)	1,420	1,130	989
Sulfide, mg/l	.4	.3	.2
Phenol, mg/l	0	0	0
Sulfite, mg/l	0	0	0
Chemical Oxygen Demand (COD), mg/l	9	5	0
Sulfate, mg/l	18.0	15.6	12.0
Fluoride, mg/l	.70	.52	.26

TABLE XI

Bromide Spring Chemical and Physical Data

Parameter	Values		
	Maximum	Average	Minimum
pH	7.8	7.6	7.4
Dissolved Oxygen (DO), mg/l	7.6	5.8	4.6
5 Day (20°C) BOD, mg/l	3.0	1.0	0.0
Total Suspended Solids, mg/l	32	-	<7.0
Total Solids, mg/l	4,697	4,527	4,406
Organic Nitrogen as (N), mg/l	0.6	-	<0.05
Ammonia Nitrogen as (N), mg/l	0.3	-	<0.05
Nitrate Nitrogen as (N), mg/l	1.2	1.0	0.8
Nitrite Nitrogen as (N), mg/l	.075	-	<.005
Total Phosphate as (P), µg/l	45	-	<10
Bromide, mg/l	4.8	4.4	4.0
Chloride, mg/l	2,360	2,300	2,240
Hardness as ($CaCO_3$), mg/l	270	244	213
Conductivity in (micromhos/cm at 25°C)	8,230	7,510	6,220
Sulfide, mg/l	.6	.3	0.0
Phenol, mg/l	0	0	0
Sulfite, mg/l	0	0	0
Chemical Oxygen Demand (COD), mg/l	324	112	29
Sulfate, mg/l	57.0	45.5	39.5
Fluoride, mg/l	1.9	1.7	1.4

TABLE XII

Medicine Spring Chemical and Physical Data

Parameter	Values		
	Maximum	Average	Minimum
pH	8.00	7.74	7.56
Dissolved Oxygen (DO), mg/l	0.0	0.0	0.0
5 Day (20ºC) BOD, mg/l	27	12	.50
Total Suspended Solids, mg/l	45	18	7
Total Solids, mg/l	5,113	4,592	4,359
Organic Nitrogen as (N), mg/l	0.5	0.2	0.1
Ammonia Nitrogen as (N), mg/l	1.2	-	<.1
Nitrate Nitrogen as (N), mg/l	.5	-	<.1
Nitrite Nitrogen as (N), mg/l	<.01	-	<.01
Total Phosphate as (P), µg/l	45	-	<10
Bromide, mg/l	2.93	2.53	2.13
Chloride, mg/l	2,720	2,390	2,260
Hardness as ($CaCO_3$), mg/l	238	208	140
Conductivity in (micromhos/cm at 25°C)	8,200	7,590	6,260
Sulfides, mg/l	5.8	1.4	0.1
Phenol, mg/l	0	0	0
Sulfite, mg/l	0	0	0
Chemical Oxygen Demand (COD), mg/l	.171	66	9
Sulfate, mg/l	69.0	53.4	26.0
Fluoride, mg/l	1.9	1.8	1.6

V. BACKGROUND

Area History

The original movement to preserve the present site of Platt National Park can probably be attributed to the Indians who feared that the final allotment of land would prevent continued use of the springs in that area. Also, settlement of the town of Sulphur Spring seemed to pose some threat to ready access to the springs.

The Indians were accustomed to camping and hunting in the vicinity of the springs long before the coming of the early settlers. The waters of these springs were used as a "cure-all" by the Indians,[18] and it was from them that the settlers learned to use these waters for medicinal purposes. The use of these waters by both has continued to present generations, and people travel great distances today to consume these waters because of the alleged therapeutic values.

It was this continuing public consumption of water from the springs that created concern on the part of park officials regarding the public health aspect of these waters. Because of this concern, the Park Service has installed chlorinating units in both Medicine and Bromide Springs. An ultra-violet light has been installed in the waterlines of Black Sulphur Spring to disinfect the waters before they are consumed by the public. No attempt has been made to treat the water from Hillside and Pavilion Springs to permit their use by the public.

Project Staff

Harold F. Cumiford, Microbiologist - Project Leader

Bobby G. Benefield, Chemist
Ralph D. Harkins, Ph. D., Mathematical Statistician
Tommy N. Redman, Engineering Aide
Baptiste B. Shunatona, Jr., Geologist

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VII. APPENDIX

UNITED STATES
DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION

ROBERT S. KERR WATER RESEARCH CENTER
POST OFFICE BOX 1198
ADA, OKLAHOMA 74820

In Reply Refer to:
D5031

National Park Service
Platt National Park
Arbuckle Recreation Area
P. O. Box 539
Sulphur, Oklahoma 73086

November 9, 1966

Mr. W. C. Galegar, Director
Robert S. Kerr Water Research Center
P. O. Box 1198
Ada, Oklahoma 74820

Dear Mr. Galegar:

We would like to request the assistance of the Research Center to locate the source of contamination in the water flowing from Hillside Spring here in Platt National Park.

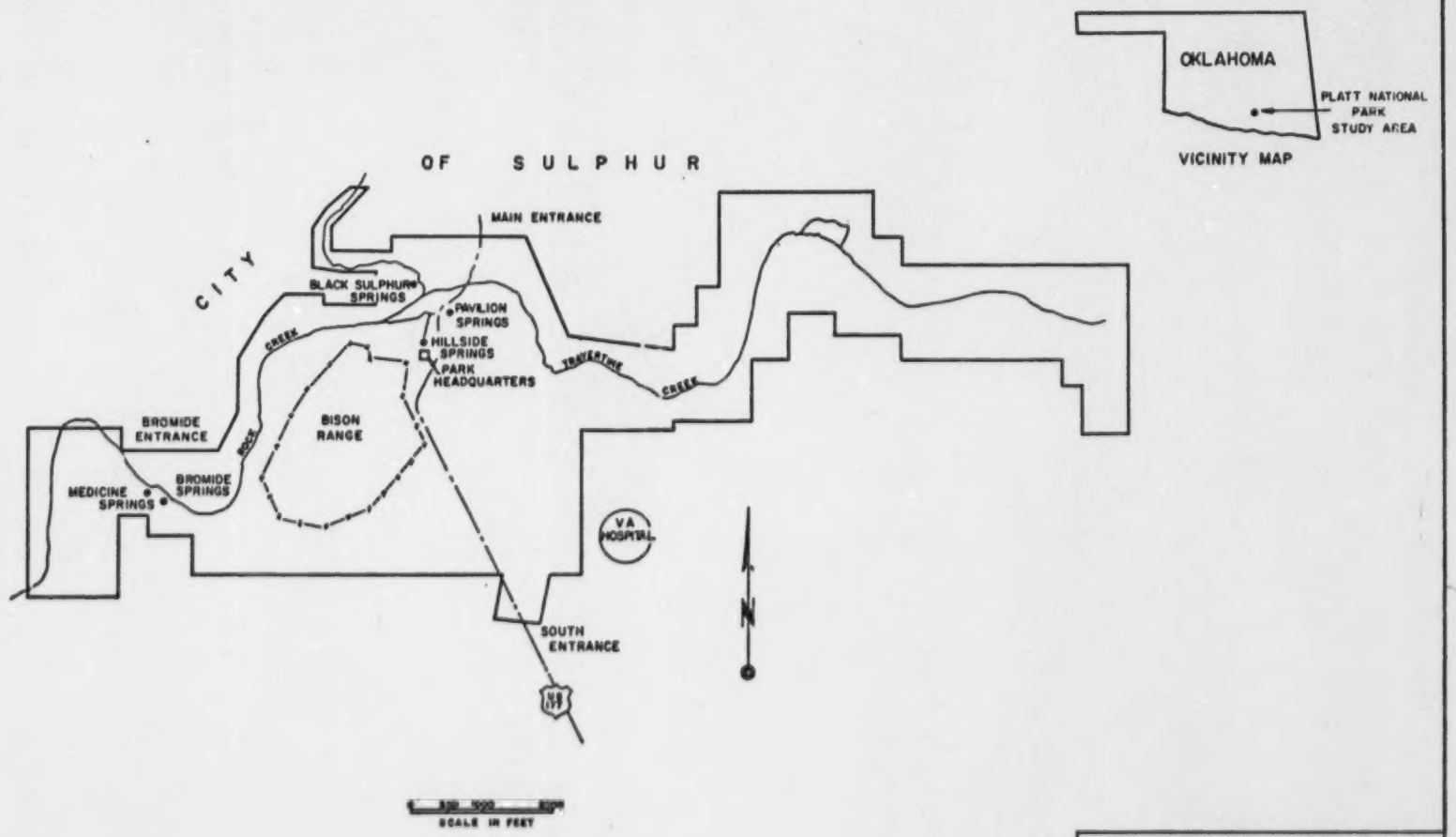
The spring has a history of positive coliform tests from water samples sent to the Oklahoma State Department of Health. In December of 1964, a new casing and cover was installed at the spring head. Since that time, about one-third of the water samples show a positive test. On November 8, 1966, Ranger William L. Germeraad of this office, discussed the contamination problem and the history of the spring with Mr. Richard Duty and Mr. Harold Cumiford of your staff.

As the spring is near a major highway running through the park, and the area surrounding the spring provides a pleasant rest spot, development of the spring for drinking purposes would be a beneficial service to the visiting public.

Thank you for your consideration of this request. Any help you may give us will certainly be appreciated.

Sincerely yours,

Robert W. Peters
Acting Superintendent



A STUDY OF THE BACTERIAL CONTAMINATION OF HILLSIDE SPRINGS AT PLATT NATIONAL PARK

LOCATION MAP

U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
ROBERT S. KERR WATER RESEARCH CENTER
ADA, OKLAHOMA

FIGURE 7